



Musculoskeletal Disorders and Workplace Factors

A Critical Review of Epidemiologic Evidence for
Work-Related Musculoskeletal Disorders of the
Neck, Upper Extremity, and Low Back



U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Public Health Service
Centers for Disease Control and Prevention
National Institute for Occupational Safety and Health



For additional information
contact NIOSH at:
National Institute for Occupational Safety and Health
Publications Dissemination
4676 Columbia Parkway
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1-800-35-NIOSH
(1-800-356-4674)

FAX number: (513) 533-8573

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Edited by:

Bruce P. Bernard, M.D., M.P.H.

Contributors:

Vern Putz-Anderson, Ph.D.

Bruce P. Bernard, M.D., M.P.H.

Susan E. Burt

Libby L. Cole, Ph.D.

Cheryl Fairfield-Estill

Lawrence J. Fine, M.D., Dr.P.H.

Katharyn A. Grant, Ph.D.

Christopher Gjessing

Lynn Jenkins

Joseph J. Hurrell Jr., Ph.D.

Nancy Nelson, Ph.D.

Robert Roberts

Diana Stetson, Ph.D.

Marie Haring-Sweeney, Ph.D.

Shiro Tanaka, M.D.

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Fax number: (513) 533-8573
E-mail: pubstaft@cdc.gov

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FOREWORD

Musculoskeletal disorders (MSDs) were recognized as having occupational etiologic factors as early as the beginning of the 18th century. However, it was not until the 1970's that occupational factors were examined using epidemiologic methods, and the work-relatedness of these conditions began appearing regularly in the international scientific literature. Since then the literature has increased dramatically; more than six thousand scientific articles addressing ergonomics in the workplace have been published. Yet, the relationship between MSDs and work-related factors remains the subject of considerable debate.

Musculoskeletal Disorders and Workplace Factors: A Critical Review of Epidemiologic Evidence for Work-Related Musculoskeletal Disorders of the Neck, Upper Extremity, and Low Back will provide answers to many of the questions that have arisen on this topic over the last decade. This document is the most comprehensive compilation to date of the epidemiologic research on the relation between selected MSDs and exposure to physical factors at work. On the basis of our review of the literature, NIOSH concludes that a large body of credible epidemiologic research exists that shows a consistent relationship between MSDs and certain physical factors, especially at higher exposure levels.

This document, combined with other NIOSH efforts in this area, will assist us in our continued efforts to address these inherently preventable disorders.



Linda Rosenstock, M.D., M.P.H.
Director, National Institute for
Occupational Safety and Health
Centers for Disease Control and Prevention

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EXECUTIVE SUMMARY

The term musculoskeletal disorders (MSDs) refers to conditions that involve the nerves, tendons, muscles, and supporting structures of the body. The purpose of this NIOSH document is to examine the epidemiologic evidence of the relationship between selected MSDs of the upper extremity and the low back and exposure to physical factors at work. Specific attention is given to analyzing the weight of the evidence for the strength of the association between these disorders and work factors.

Because the relationship between exposure to physical work factors and the development and prognosis of a particular disorder may be modified by psychosocial factors, the literature about psychosocial factors and the presence of musculoskeletal symptoms or disorders is also reviewed. Understanding these associations and relating them to the cause of disease is critical for identifying exposures amenable to preventive and therapeutic interventions.

MAGNITUDE OF THE PROBLEM

The only routinely collected national source of information about occupational injuries and illnesses of U.S. workers is the Annual Survey of Occupational Injuries and Illnesses conducted by the Bureau of Labor Statistics (BLS) of the U.S. Department of Labor. The survey, which BLS has conducted for the past 25 years, is a random sample of about 250,000 private sector establishments and provides estimates of workplace injuries and illnesses on the basis of information provided by employers from their OSHA Form 200 log of recordable injuries and illnesses.

For cases involving days away from work, BLS reports that in 1994 (the last year of data available at the time this report was prepared) approximately **705,800** cases (32%) were the result of overexertion or repetitive motion. Specifically, there were

- **367,424** injuries due to overexertion in lifting (65% affected the back); **93,325** injuries due to overexertion in pushing or pulling objects (52% affected the back); **68,992** injuries due to overexertion in holding, carrying, or turning objects (58% affected the back). Totaled across these three categories, **47,861** disorders affected the shoulder.
- **83,483** injuries or illnesses in other and unspecified overexertion events.

- **92,576** injuries or illnesses due to repetitive motion, including typing or key entry, repetitive use of tools, and repetitive placing, grasping, or moving of objects other than tools. Of these injuries or illnesses, 55% affected the wrist, 7% affected the shoulder, and 6% affected the back.

Data for 1992 to 1995 indicate that injuries and illnesses requiring days away from work declined 19% for overexertion and 14% for repetitive motion. The incidence rate of overexertion (in lifting) declined from 52.1 per 10,000 workers in 1992 to 41.1 in 1995; the incidence rate for repetitive motion disorders declined from 11.8 per 10,000 workers in 1992 to 10.1 in 1995. These declines are similar to those seen for cases involving days away from work from all causes of injury and illness.

The reasons for these declines are unclear, but may include: a smaller number of disorders could be occurring because of more intensive efforts to prevent them, more effective prevention and treatment programs could be reducing days away from work, employers or employees may be more reluctant to report or record disorders, or the criteria used by health care providers to diagnose these conditions could be changing.

IDENTIFICATION AND SELECTION OF STUDIES

The goal of epidemiologic studies is to identify factors that are associated (positively or negatively) with the development or recurrence of adverse medical conditions. This evaluation and summary of the epidemiologic evidence focuses chiefly on disorders that affect the neck and the upper extremity, including tension neck syndrome, shoulder tendinitis, epicondylitis, carpal tunnel syndrome, and hand-arm vibration syndrome, which have been the most extensively studied in the epidemiologic literature. The document also reviews studies that have dealt with work-related back pain and that address the way work organizational and psychosocial factors influence the relationship between exposure to physical factors and work-related MSDs. The literature about disorders of the lower extremity is outside the scope of the present review.

A search strategy of bibliographic databases identified more than 2,000 studies. Because of the focus on the epidemiology literature, studies that were laboratory-based or focused on MSDs from a biomechanical standpoint, dealt with clinical treatment of MSDs, or other non-epidemiologic orientation were eliminated from further consideration for this document. Over 600 studies were included in the detailed review process.

METHODS FOR SYNTHESIZING STUDIES

For the upper extremity studies included in this review, those which used specific diagnostic criteria, including physical examination techniques, are given greater consideration than studies that used less specific methods to define health outcomes. The review focused most strongly on observational studies whose health outcomes were based on recognized symptoms and standard methods of clinical examination. For completeness, those epidemiologic studies that based their health outcomes on reported symptoms alone were also reviewed. For the low back studies included in this review, those which had objective exposure measurements were given greater

consideration than those which used self-reports or other measures. For the psychosocial section, any studies which included measurement or discussion of psychosocial factors and MSDs were included.

No single epidemiologic study will fulfill all criteria to answer the question of causality. However, results from epidemiologic studies can contribute to the evidence of causality in the relationship between workplace risk factors and MSDs. The framework for evaluating evidence for causality in this review included strength of association, consistency, temporality, exposure-response relationship, and coherence of evidence.

Using this framework, the evidence for a relationship between workplace factors and the development of MSDs from epidemiologic studies is classified into one of the following categories:

Strong evidence of work-relatedness (+++). A causal relationship is shown to be very likely between intense or long duration exposure to the specific risk factor(s) and MSD when the epidemiologic criteria of causality are used. A positive relationship has been observed between exposure to the specific risk factor and MSD in studies in which chance, bias, and confounding factors could be ruled out with reasonable confidence in at least several studies.

Evidence of work-relatedness (++). Some convincing epidemiologic evidence shows a causal relationship when the epidemiologic criteria of causality for intense or long duration exposure to the specific risk factor(s) and MSD are used. A positive relationship has been observed between exposure to the specific risk factor and MSD in studies in which chance, bias, and confounding factors are not the likely explanation.

Insufficient evidence of work-relatedness (+/0). The available studies are of insufficient number, quality, consistency, or statistical power to permit a conclusion regarding the presence or absence of a causal association. Some studies suggest a relationship to specific risk factors but chance, bias, or confounding may explain the association.

Evidence of no effect of work factors (-). Adequate studies that consistently show that the specific workplace risk factor(s) is not related to development of MSD.

The classification of results in this review by body part and specific risk factor are summarized in Table 1.

Table 1. Evidence for causal relationship between physical work factors and MSDs

Body part <i>Risk factor</i>	Strong evidence (+++)	Evidence (++)	Insufficient evidence (+/0)	Evidence of no effect (-)
Neck and Neck/shoulder				
<i>Repetition</i>		✓		
<i>Force</i>		✓		
<i>Posture</i>	✓			
<i>Vibration</i>			✓	
Shoulder				
<i>Posture</i>		✓		
<i>Force</i>			✓	
<i>Repetition</i>		✓		
<i>Vibration</i>			✓	
Elbow				
<i>Repetition</i>			✓	
<i>Force</i>		✓		
<i>Posture</i>			✓	
<i>Combination</i>	✓			
Hand/wrist				
Carpal tunnel syndrome				
<i>Repetition</i>		✓		
<i>Force</i>		✓		
<i>Posture</i>			✓	
<i>Vibration</i>		✓		
<i>Combination</i>	✓			
Tendinitis				
<i>Repetition</i>		✓		
<i>Force</i>		✓		
<i>Posture</i>		✓		
<i>Combination</i>	✓			
Hand-arm vibration syndrome				
<i>Vibration</i>	✓			
Back				
<i>Lifting/forceful movement</i>	✓			
<i>Awkward posture</i>		✓		
<i>Heavy physical work</i>		✓		
<i>Whole body vibration</i>	✓			
<i>Static work posture</i>			✓	

CONCLUSIONS

A substantial body of credible epidemiologic research provides strong evidence of an association between MSDs and certain work-related physical factors when there are high levels of exposure and especially in combination with exposure to more than one physical factor (e.g., repetitive lifting of heavy objects in extreme or awkward postures) [Table 1].

The strength of the associations reported in the various studies for specific risk factors after adjustments for other factors varies from modest to strong. The largest increases in risk are generally observed in studies with a wide range of exposure conditions and careful observation or measurement of exposures.

The consistently positive findings from a large number of cross-sectional studies, strengthened by the limited number of prospective studies, provides *strong evidence* (+++) for increased risk of work-related MSDs for some body parts. This evidence can be seen from the strength of the associations, lack of ambiguity in temporal relationships from the prospective studies, the consistency of the results in these studies, and adequate control or adjustment for likely confounders. For some body parts and risk factors there is some *epidemiologic evidence* (++) for a causal relationship. For still other body parts and risk factors, there is either an insufficient number of studies from which to draw conclusions or the overall conclusion from the studies is equivocal. The absence of existing epidemiologic evidence should not be interpreted to mean there is no association between work factors and MSDs.

In general, there is limited detailed quantitative information about exposure-disorder relationships between risk factors and MSDs. The risk of each exposure depends on a variety of factors such as the frequency, duration, and intensity of physical workplace exposures. Most of the specific exposures associated with the *strong evidence* (+++) involved daily whole shift exposure to the factors under investigation.

Individual factors may also influence the degree of risk from specific exposures. There is evidence that some individual risk factors influence the occurrence of MSDs (e.g., elevated body mass index and carpal tunnel syndrome or a history of past back pain and current episodes of low back pain). There is little evidence, however, that these individual factors interact synergistically with physical factors. All of these disorders can also be caused by nonwork exposures. The majority of epidemiologic studies involve health outcomes that range in severity from mild (the workers reporting these disorders continue to perform their routine duties) to more severe disorders (workers are absent from the workplace for varying periods of time). The milder disorders are more common. A limited number of studies investigate the natural history of these disorders and attempt to determine whether continued exposure to physical factors alters their prognosis.

The number of jobs in which workers routinely lift heavy objects, are exposed on a daily basis to whole body vibration, routinely perform overhead work, work with their necks in chronic flexion position, or perform repetitive forceful tasks is unknown. While these exposures do not occur in

most jobs, a large number of workers may indeed work under these conditions. The BLS data indicate that the total employment is over three million in the industries with the highest incidence rates of cases involving days away from work from overexertion in lifting and repetitive motion. Within the highest risk industries however, it is likely that the range of risk is substantial depending on the specific nature of the physical exposures experienced by workers in various occupations within that industry.

This critical review of the epidemiologic literature identified a number of specific physical exposures strongly associated with specific MSDs when exposures are intense, prolonged, and particularly when workers are exposed to several risk factors simultaneously. This scientific knowledge is being applied in preventive programs in a number of diverse work settings. While this review has summarized an impressive body of epidemiologic research, it is recognized that additional research would be quite valuable. The MSD components of the National Occupational Research Agenda efforts are principally directed toward stimulation of greater research on MSDs and occupational factors, both physical and psychosocial. Research efforts can be guided by the existing literature, reviewed here, as well as by data on the magnitude of various MSDs among U.S. workers.

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Vanessa Becks
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Sue Feldmann
Sean Gallagher
Lytt Gardner, Ph.D.
Pamela Graydon
Daniel Habes
Rose Hagedorn
William Halperin, M.D., Sc.D.
Anne Hamilton
Susan Hogan
Hongwei Hsiao, Ph.D.
Lore Jackson
Laurel Jones
Susan Kaelin
Sandy Kasper

Aileen Kiel
Diana Kleinwachter
Nina Lalich
Leslie MacDonald
Diane Manning
James McGlothlin, Ph.D.
Patricia McGraw
Alma McLemore
Judy Meese
Matthew Miller
Kathleen Mitchell
Marty Petersen
Donna Pfirman
Linda Plybon
Steven Sauter, Ph.D.
Mitch Singal, M.D.
Becky Spry
Naomi Swanson, Ph.D.
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Gunnar B.J. Andersson, M.D., Ph.D.
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Robert Harrison, M.D., M.P.H.
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Mohammed M. Ayoub, Ph.D., P.E., C.P.E.
Texas Tech University

Sidney J. Blair, M.D., F.A.C.S.
Loyola Chicago University

Vance C. Calvez, M.S., C.P.E.
The Joyce Institute

Don B. Chaffin, Ph.D.
University of Michigan

Jerome J. Congleton, Ph.D., P.E., C.P.E.
Texas A&M University

Thomas Cook, Ph.D., P.T.
University of Iowa

Theodore Courtney
Liberty Mutual

Michael Feuerstein, Ph.D.
Uniformed Services University
of the Health Sciences

Eric Frumin
Union of Needle Trades, Industrial,
and Textile Employees (UNITE)

Michael Gauf
CTD News

Fred Gerr, M.D.
Emory University

Lawrence P. Hanrahan, Ph.D., M.S.
Wisconsin Division of Health

Barbara Silverstein, Ph.D., M.P.H., C.P.E.
State of Washington Department of Labor
and Industries

William S. Marras, Ph.D.
The Ohio State University

J. Steven Moore, M.D., M.P.H., C.I.H., C.P.E.
University of Texas Health Center at Tyler

Margareta Nordin, Dr. Med. Sc.
New York University

Donald C. Olsen, Jr., C.S.P., C.P.E.
ERGOSH

Thomas Owens, C.I.H., P.E.
IBM Corporation

Malcolm H. Pope, Dr. Med. Sc., Ph.D.
The University of Iowa

Laura Punnett, Sc.D.
University of Massachusetts

Robert G. Radwin, Ph.D.
University of Wisconsin-Madison

David Rempel, M.D.
University of California, San Francisco

Suzanne H. Rodgers, Ph.D.
Consultant in Ergonomics

C. Jivan Saran
Central Missouri State University

Scott Schneider, C.I.H.
The Center to Protect Workers' Rights

